EARTH ORBITAL PAYLOAD PLANNING

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ABSTRACT

Processing and manufacture of materials in orbit is shown as one of the more promising elements of future earth orbital payloads. Plans for including it in the experiments program of the next decade are outlined and compared with preliminary planning for flight programs in this period. Space vehicles such as the AAP Workshops, the Space Station and the Shuttle are described and related to program planning for processing and manufacture of materials in orbit. Some of the major milestones in the evolution of such a program are also described. Industrial organizations will be responsible for a major part of this effort; therefore, procedures for soliciting and selecting industrial inputs are reviewed and some policy guidelines related to funding and proprietary rights of involved industrial organizations are considered.

INTRODUCTION

The United States declared its determination to lead the world in space technology at the beginning of this decade and has carried it out by a tremendous program of flight technology development in the 1960's. Our success has been demonstrated

by the Apollo lunar landing, the Mariner Mars missions, and many other accomplishments.

To maintain and extend the leadership we have gained, we now need to consolidate the last decade's technological advances by applying them productively, for space flight's long-range future depends on its paying its way by dividends in terms of scientific knowledge, direct economic benefits, and security-related technology. To secure such dividends, we shall need to carry out substantial developmental and experimental efforts in the coming decade.

POTENTIAL FOR MATERIALS PROCESSING

Lately it has been pointed out that the weightless conditions in an orbiting spacecraft offer some unique advantages for work on materials and processes that can yield valuable returns in all three of the areas mentioned above. Part of this idea's appeal comes from prospects for producing materials in new forms, but much of it also comes from the fact that some processes carried out in zero "g" may add enough value to their raw materials to enable space operations to show a profit. Interest in these prospects has been lively; a number of potentially useful processes have been identified, and Government and industry teams are currently evaluating them.

Some of these processes are listed in Figure 1; since other papers at this meeting will discuss them in detail, only a few comments will be in order here. Most of these proposals concern processes in metallurgy: either the familiar kind that deals with metals or the sophisticated new metallurgy of semiconductors and other electronic materials. The chemical field has been explored much less, and so far the only definite proposals seem to be to exploit the advantages of weightlessness in physical methods of chemical separation that are important in biological processing.

It seems clear that this is only a beginning, and we feel confident that many other areas of interest for industrial application have yet to be identified. If the field develops as most other technologies have, we can expect that the most valuable and far-reaching ideas will be uncovered after research efforts are well under way, and by active workers in the program. The major purpose of this meeting is to arouse your interest and solicit your participation in exploring this promising new area of science and technology.

SPACE FLIGHT PROGRAM PLANNING

We have talked briefly about the significance of a program for materials processing in space. This leads to a natural question from any of you interested in this kind of activity; what flight programs and mission capabilities are being planned over the next decade suitable for this type of research? As you fully realize, our future space effort is highly dependent on the national interest and availability of funds to carry on this exploration. However, we in NASA are optimistic and are planning a very aggressive program of space activities in the seventies.

A schedule of earth orbital missions in the manned program as developed in the plan for an "Integrated Space Program for the 70's" is shown in Figure 2. The current plan for the Apollo Applications Program (AAP) calls for launching a ground configured Workshop (shown in Figure 3) unmanned on a Saturn V vehicle in mid-1972. The orbit will be at 270 mile altitude and moderate inclination angle. This is followed by a series of three manned logistic launches to permit occupancy of the Station for periods of nominally one month, two months, and two months respectively. The exact sequencing and time phasing of these launches have not been fully established but intermittent periods of dormancy are planned.

The Station is designed to accommodate a crew of three and, as shown by Figure 3, the crew is quartered in the basic Workshop. Sufficient expendables are launched with the Workshop

to accommodate the entire mission sequence. A docking adaptor is provided for docking the CSM with the Workshop during periods of manned operation.

The mission is intended to extend the period of astronaut exposure to zero "g", verify his compatibility with this environment, evaluate the suitability of the design of his surroundings and carry out a number of significant scientific and technological investigations. Major experiment areas are

medical evaluations,
habitability & crew performance studies, and
ATM solar astronomy.

Included in the experiment complement of the Workshop are the M-512, Materials Processing, investigations described later in the paper.

Current planning considers following the first Workshop with a second one launched in early 1974. This Workshop would be the same basic configuration as the first but with new and improved payloads. Planning calls for at least four manned logistic missions spaced at 90-day intervals to support the program. The second Workshop is planned to be continuously manned with a crew complement of three and will be designed for an operating life of 12-18 months. It would operate at an altitude between 210 and 270 miles at an inclination up to 55^{o}.

Payloads for this program will emphasize the experimental facility approach with the idea that NASA will provide basic research laboratories available to participating scientists and engineers to carry out investigations of interest and value to the various disciplines.

Major payload elements for the Workshop may include:

A follow-on ATM Astronomy Module
An Earth Resources Package

A Modest Hi-Energy Physics Lab.
A Life Sciences Payload

An improved facility for materials processes research is also planned for this program.

Work will also have been initiated to develop a Space Station for launch in 1975. This would be the initial vehicle which serves as the basic building block for assembly of a space base available for use by the end of the decade. A fully operational space base would be capable of supporting up to 100 men of various disciplines, including scientists, engineers, and technicians.

The Space Station (conceptually illustrated on Figure 4) considered for this period is significantly more advanced than the Saturn Workshop. Our goal is to establish a multi-purpose, general use station capable of satisfying operational objectives in a variety of disciplines. It is intended for long life (5-10 years) and will be designed for in-orbit check-out and maintenance. Flexibility and adaptability will be attained through a modular approach as illustrated on Figure 5. Modules would be developed as living quarters, command and control stations, basic subsystem modules and experiment modules. In this way we hope to obtain a level of versatility, adaptability and safety suitable for the type program planned for the late 70's. With this design concept, it is expected that the Space Station modules would be adaptable for build-up of an earth orbiting space base, a geosynchronous station, a lunar orbiting station and ultimately a spacecraft suitable for interplanetary travel.

A major part of the earth orbiting program in the late 70's will be devoted to scientific, technological and applications experimentation. The experiment modules planned for the station are designed uniquely to support investigations in various disciplines. These modules may be segments of the basic station as illustrated in Figure 6, or free flying as shown in Figure 7.

If we are to maximize the benefits afforded by a space station, however, it is essential to reduce costs associated with transporting payloads to orbit. Recognizing these needs, the Space Agency has set as a paramount goal for the 70's the development of a cheap transportation system to orbit—the Space Shuttle. Today it costs from $500 to $1500 a pound to launch payloads to orbit. With a space shuttle it is hoped to cut these costs by at least an order of magnitude. To achieve this cost reduction, the shuttle would be designed for reusability much as today's modern jet liners are.

A number of alternatives are currently under investigation and several aerospace organizations are studying the problem. Based upon these studies, the more promising configurations would be carried into a Phase B evaluation. An example of such a vehicle is shown in Figure 8. It consists of two stages—fully reusable. The operational concept of such a system is shown in Figure 9. The initial stage would launch the spacecraft and, upon depletion of fuel would return to base. The second stage would continue on to orbit and deliver its payload. Once in orbit, it would rendezvous with the Space Station, off-load its payload and pick up return cargo. The shuttle would then separate from the Space Station, de-orbit and return to base where it would be readied for a subsequent mission.

Our planning calls for development of such a system for flight by 1975 (Figure 2). As flight experience is achieved, scheduled operation would increase as shown in Figure 2 until, by the end of the decade, flight frequencies approaching 100 per year would be attained.

PROGRAM DEVELOPMENT FOR SPACE PROCESSING OF MATERIALS

We can now begin to define a program for space processing of materials utilizing this capability, based on the earth orbital planning outlined above. Since we are only beginning in this new

field of endeavor, our program must allow for an orderly evolution from basic research through exploratory investigations of potentially promising processes to eventual commercial production of economically feasible products. The flight program also must be coupled with a substantial effort in ground-based research and experimentation, particularly in the early phases, and should involve the support of Government and university groups, as well as industrial organizations.

Within NASA, close coordination has been established between Manned Space Flight and the Advanced Research & Technology Office, and we are jointly sponsoring effort directed toward a common program in this area.

Although no detailed program plan has been developed as yet, Figure 10 outlines a general approach we are considering. As indicated on this chart, a number of contracted and in-house studies are already under way to develop better understanding of processes affected by gravity and to determine the interests of industrial organizations in space processing of materials for commercial application. This work is outlined in more detail in the next chart (Figure 11). As shown on this figure, our effort encompasses a broad range of activity including: 1) theoretical research; 2) investigations of specific processes sensitive to a weightless environment; 3) surveys of industrial organization to establish their needs; and 4) studies leading to design of a flight facility for investigations in space.

Preliminary experiments in the materials processing area are planned for the first Workshop. Much of our current effort is directed to the definition and development of these experiments for flight. Our present activity is quite limited, however, and the facility available in which to carry out these studies is modest. A schematic of the Workshop processing unit is shown in Figure 12. It consists basically of a chamber to provide a safe and evacuated space in which to conduct our studies. In addition, it is equipped with a control panel, a power supply, and a number of experiment packages to study various processes in

flight. Figure 13 lists the various experiments planned for the missions. Papers to be presented later in the conference will discuss both the facility and the planned experiments in more detail. A number of papers also will review in depth many of the supporting studies noted earlier.

These flight experiments and supporting studies should provide a substantive base from which to progress into a more ambitious effort on the second Workshop. It is unlikely, however, that we will have reached a point where commercial application is a reality. Rather, we think it will be necessary to continue our exploratory effort through more ground-based studies of promising processes and development of flight experiments to verify concepts. This is how we have structured our program approach as shown in Figure 10. We would expect to handle more complex processes than on the first Workshop and allow verification of certain techniques proposed by industrial organizations which may have commercial application. The flight facility envisioned for this phase would be improved and more versatile than our initial chamber. It probably will consist of several elements for positioning, heating and processing materials, for growing crystals, and for blending of composites. Hopefully, it will be capable of accommodating experiments developed late in the program and carried up to the Workshop on resupply missions.

By the mid-70 time period when the Space Station becomes available, we should have progressed so that we can identify processes that are commerically attractive. A major share of the responsibility for determining and developing these experiments and processing equipment should be assumed by industry.

NASA plans to provide a capability for carrying out investigations of industrial processes both within the confines of the basic station and later in a detachable module. It is doubtful if either the funding or the technology will be available to provide an independent module for operation at the beginning of the Space Station program. Rather, it is expected that a more advanced

facility, evolving from our previous chambers, will still be of value and provide the necessary continuity to bridge the gap between the second Workshop and a separate module. Thus, in our program approach we have included a third generation space processing laboratory, integral to the Station for continuing materials processing studies. Since the Space Station will be functional for five to ten years, this laboratory should maintain its utility for an extended period of time. It need not become outmoded when the Space Manufacturing module becomes available and should be designed with sufficient flexibility to allow updating and expansion in orbit. Space processing equipment could then be developed and delivered well downstream of program initiation for use with this expanded facility (shown by the hatched bars on Figure 10).

By the late 70's we should have acquired sufficient experience to justify deployment of an independent module for space manufacturing. It would be capable of supporting commercial production of economically feasible products growing out of earlier investigations. A concept for such a module is shown in Figure 14. It could be operated either attached to the mother ship or separate in a free flying mode when environmental conditions for certain processes dictate. This module might be thought of as our initial plant or factory in space, utilized by industry for profitable operation. Initially it would be Government-owned and operated, leasing space to industrial organizations for their special needs. Ultimately it, or facilities like it, could be privately-owned and operated much as COMSAT is today.

INDUSTRIAL PARTICIPATION

I have briefly reviewed some of our future planning for earth orbital missions and outlined a program approach in the area of materials processing. This gives rise to a rather obvious question of interest to you. What is the mechanism by which industry becomes involved in such a program and submits ideas for investigation?

Precedent does exist in NASA for soliciting participation in the science area. Where opportunity exists for flying various classes of experiments on a planned space mission, the Agency issues what is called an "Announcement of Flight Opportunity" (AFO). The AFO is issued by the responsible Program Office as an open invitation to any qualified participant wishing to submit a proposed investigation for flight.

As briefly outlined in Figure 15, the AFO describes the type of mission being planned and defines the characteristics of the space vehicle on which the investigations would be flown. Sufficient detail would be included so that a potential investigator could determine whether or not there is general compatibility between the planned mission and the research contemplated.

Since a variety of science, applications and technology disciplines will be studied in the earth orbital program, the AFO would identify the category or class of investigations being solicited. For example, since future lunar missions afford an opportunity to conduct research in lunar orbit, an AFO was issued to the scientific community requesting specific proposals for lunar orbital science experiments.

Major milestones leading to experiment development and flight are identified. Dates for such major events as submission of proposals, anticipated time for experiment selection, delivery of flight hardware, and planned flight period would be specified.

Finally, instructions for preparing and submitting proposals would be included. A specific form has been developed by NASA for this purpose. (Experiment Proposal, NASA Form #1346) The form is not described in this paper, but interested organizations can obtain copies of this form from the forms distribution offices at NASA Headquarters or MSFC.

Manned Space Flight is expected to adopt the AFO approach for soliciting proposals for materials processing investigation on future missions. If approval is obtained for a second

Workshop mission, an announcement of flight opportunity would be issued to interested organizations some time next year.

Assuming an organization submits a proposed experiment for flight, one would then logically ask, "What procedure is used by NASA in the selection of proposed experiments for flight?" Figure 16 schematically diagrams the major steps followed in this selection process. As shown here, the activity is initiated by issuance of an AFO. Upon receipt of a proposed investigation, the Program Office would transmit it to a Field Center (MSC, MSFC, etc.) for evaluation both in terms of technical content and applicability to the experiment program. Similar reviews also would be carried out by competent people within the Program Office. Upon completion of these reviews, recommendations for either selection or rejection of the proposal would be made to the Program Office. It is the responsibility of the Program Office to decide from among the experiments.

In most cases, experiments selected will go through a period of definition and assessment for flight compatibility prior to submission of the proposal to the Manned Space Flight Experiments Board (MSFEB) for review and approval for flight. It is the function of this Board to give final approval for flight of selected experiments. Approved experiments would then be assigned to a Flight Program Office (AAP, Apollo, etc.) for development and implementation.

A final question of interest to you relates to NASA policy for funding development and flight of materials processing proposals and the rights of the proposing organization to treat acquired data in a privileged or proprietary manner. This question is currently under review by our legal, procurement, and industrial relations staffs. No formal policy has been established yet; however, our objective is to encourage private utilization of our space capability. To this end we would adopt a policy as liberal as is practically consistent with public interest in accommodating industrial involvement.

In a real sense, it may not be practical to establish a fixed policy because of wide variance in each situation. Therefore, Government-industry relations will probably be established on a case by case basis, and the needs of industry will have considerable influence on what agreements are reached. So far, our review of Government-industry relations in space manufacturing has concentrated on developing preliminary guidelines on the basis of the existing precedents. Only general guidelines are possible at this stage, because of differing circumstances. However, to illustrate how our objective might be approached in some specific cases, we have selected four categories of possible industry-Government relations for discussion in this paper. These are outlined in Figure 17, which lists the important characteristics in each case and shows what policies and precedents could be applied.

The first category is representative of most experiment activity currently undertaken by NASA. Proposals are solicited for technical work in accordance with a work statement expressing ideas that originated within the Government or from a source having no proprietary rights in such ideas. A contract is let to the best-qualified bidder in a competitive selection, and all experiment definition, hardware design, and flight experimentation is funded by NASA. For this situation, policy has been established which grants the investigating organization undisturbed access to all data derived from the experiment for a specified period. Terms for such access are negotiated in the contract with the investigating organization. At the end of this period, results must be published for general distribution, and use and rights to all data and inventions are retained by the Government.

The second category considers a case where a private organization has conceived a promising idea and performed a certain amount of research on it, using private funds. Believing that the idea would be appropriate for space experimentation, the company submits an unsolicited proposal for NASA for support; justification is established for a sole-source procurement, and NASA grants a contract to the company for experiment develop-

ment, flight, and reduction of data.

In this case the company enters on its contract with a certain amount of equity in the basic idea, and its unique competence for further development is recognized by the sole-source procurement. Whatever proprietary rights were generated by its prior research will remain secure under any NASA contract because the National Aeronautics and Space Act does not require public ownership of background rights. Whenever such proprietary rights are to be obtained by NASA, they must be acquired by specific negotiation. With respect to rights in data and inventions resulting from the work done under contract, however, the sole-source contractor will be in much the same position as the winner of a competitive procurement. Private patent rights can only result if the Administrator of NASA finds it in the public interest to waive ownership, and in that event the Government retains a royalty-free, nonexclusive license to practice the invention.

In the third category we consider the case of a cooperative agreement involving substantial private investment. A private company conceives a promising idea for space manufacturing and desires to retain the fullest possible rights in development information and any resulting patents. It therefore proposes to develop a flight experiment and build the necessary apparatus, using its own funds, with NASA having the responsibility for integration and flight of the apparatus.

It seems probable that arrangements striking a satisfactory balance between public and private rights can be made for this class of activity. It should certainly be possible to make arrangements whereby the industrial participant would perform no work for NASA except tasks relating to vehicle integration and the like, where the proprietary idea would not be involved. On the other hand, NASA would always have some legitimate interest in scientific aspects of the experiment itself, which could not be ignored in an acceptable cooperative agreement. This interest would have to be covered by an arrangement to

publish a reasonably full description of the experiment and its results. The technical depth of disclosure could be negotiated, however, and therefore we expect that publication could be accomplished without unduly compromising the company's proprietary rights.

Our last category is an example of the kind of arrangement that might be made for actual manufacturing of a fully developed product. We suppose that the manufacturer has developed the product wholly with his own funds, so that he has an uncompromised proprietary interest in it, and that he intends to market it commercially. He seeks to lease space in a NASA space station for his operations and to use the services of NASA launch and reentry vehicles for transportation on a pay as you go basis.

Our legal staff is of the opinion that authority for such an arrangement exists in the Space Act, and there are other precedents for private use of NASA facilities in the Unitary Wind Tunnel Act and the Communication Satellite Corporation arrangement. In this case the Government is fully compensated for its services and has no vested interest in the industrial undertaking. Therefore, we would assume in this case that all data, inventions and products would belong exclusively to the private concern.

In concluding, I would like to reiterate that no formal policy exists for developing agreements for industrial exploitation of space. However, our interest is to encourage participation to the maximum extent possible. I would emphasize that formulation of policy in this area will be strongly influenced by the views of industry and the propositions they suggest in response to the opportunities that space manufacturing affords.

PROMISING MATERIAL PROCESSES IN A WEIGHTLESS ENVIRONMENT

- GROWTH OF LARGE DISLOCATION FREE SINGLE CRYSTALS
- LEVITATION CASTING OF MATERIALS
- BLENDING OF DISSIMILAR MATERIALS
- FOAM CASTING
- 'G' SENSITIVE CHEMICAL PROCESSES
- SURFACE TENSION CASTING

FIGURE 1

INTEGRATED SPACE FLIGHT MISSION PLANNING

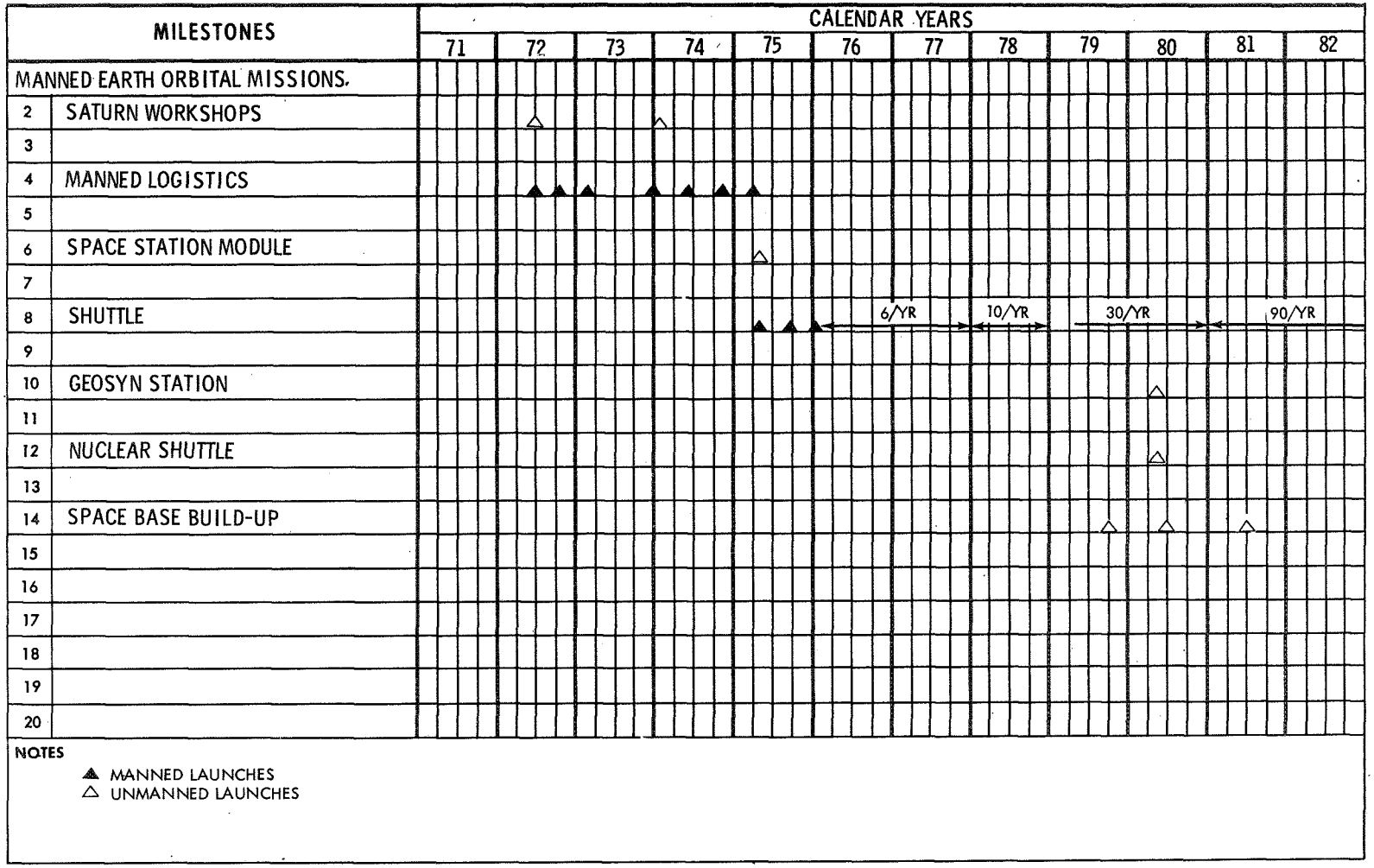


FIGURE 2

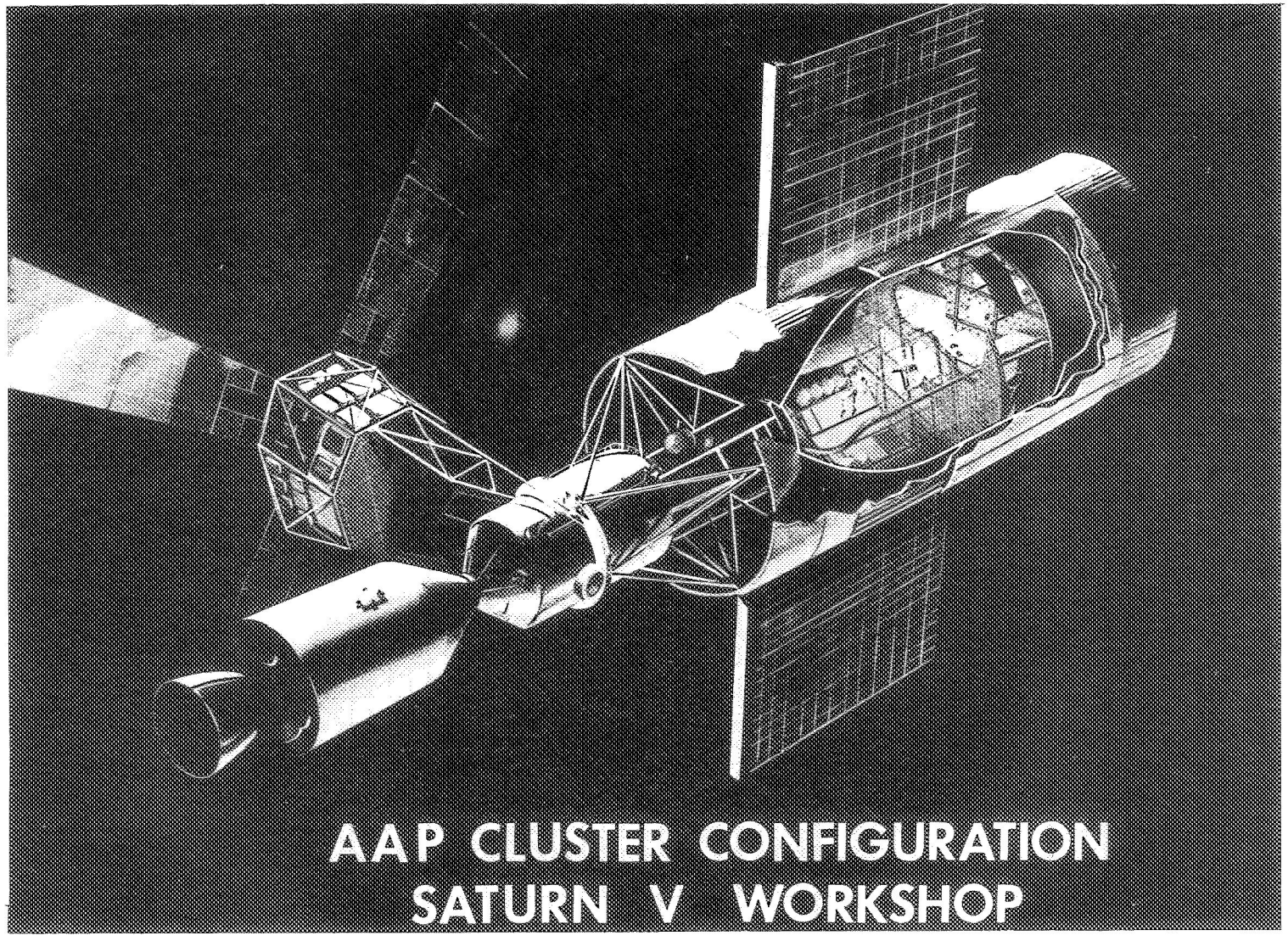


FIGURE 3

SPACE STATION

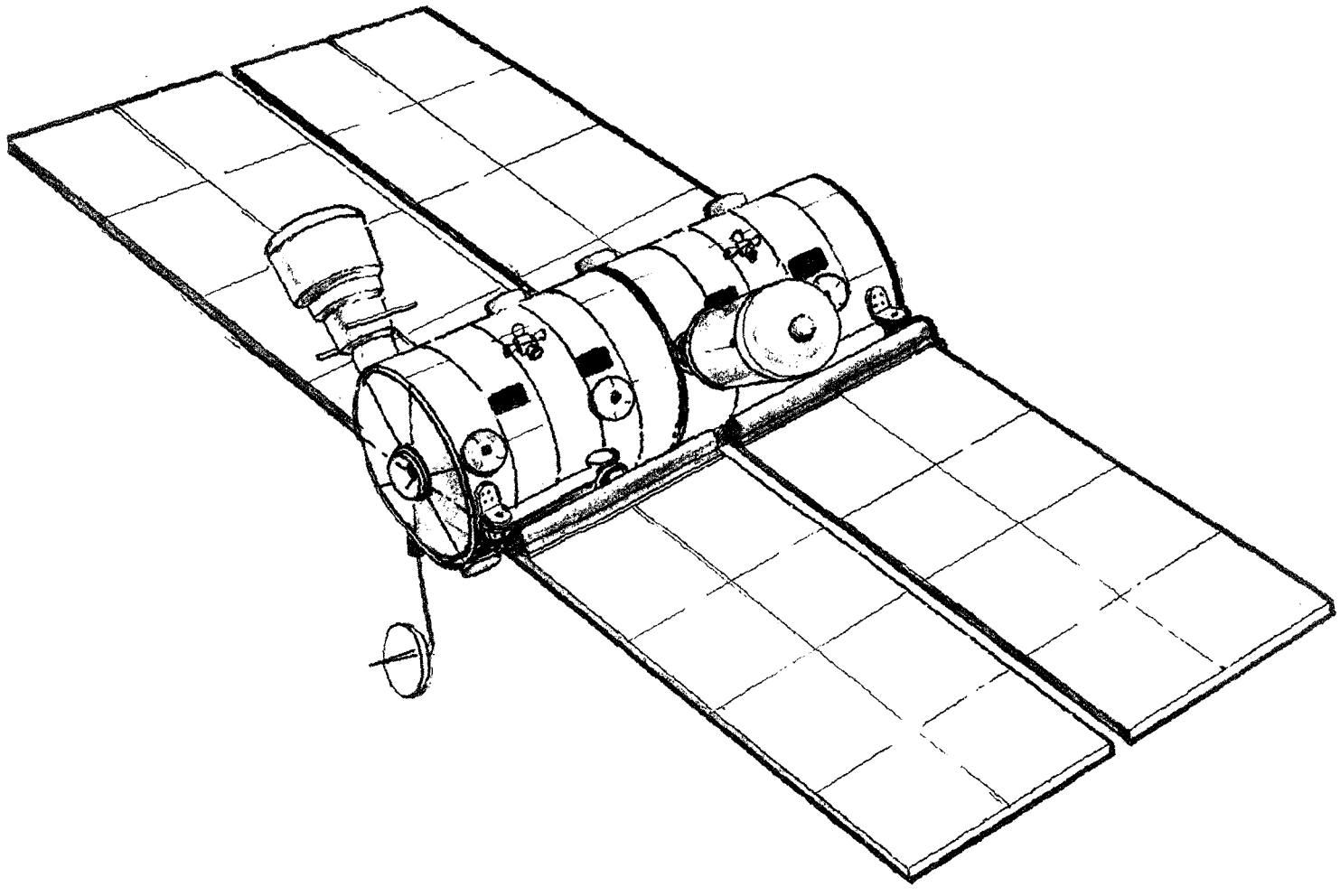


FIGURE 4

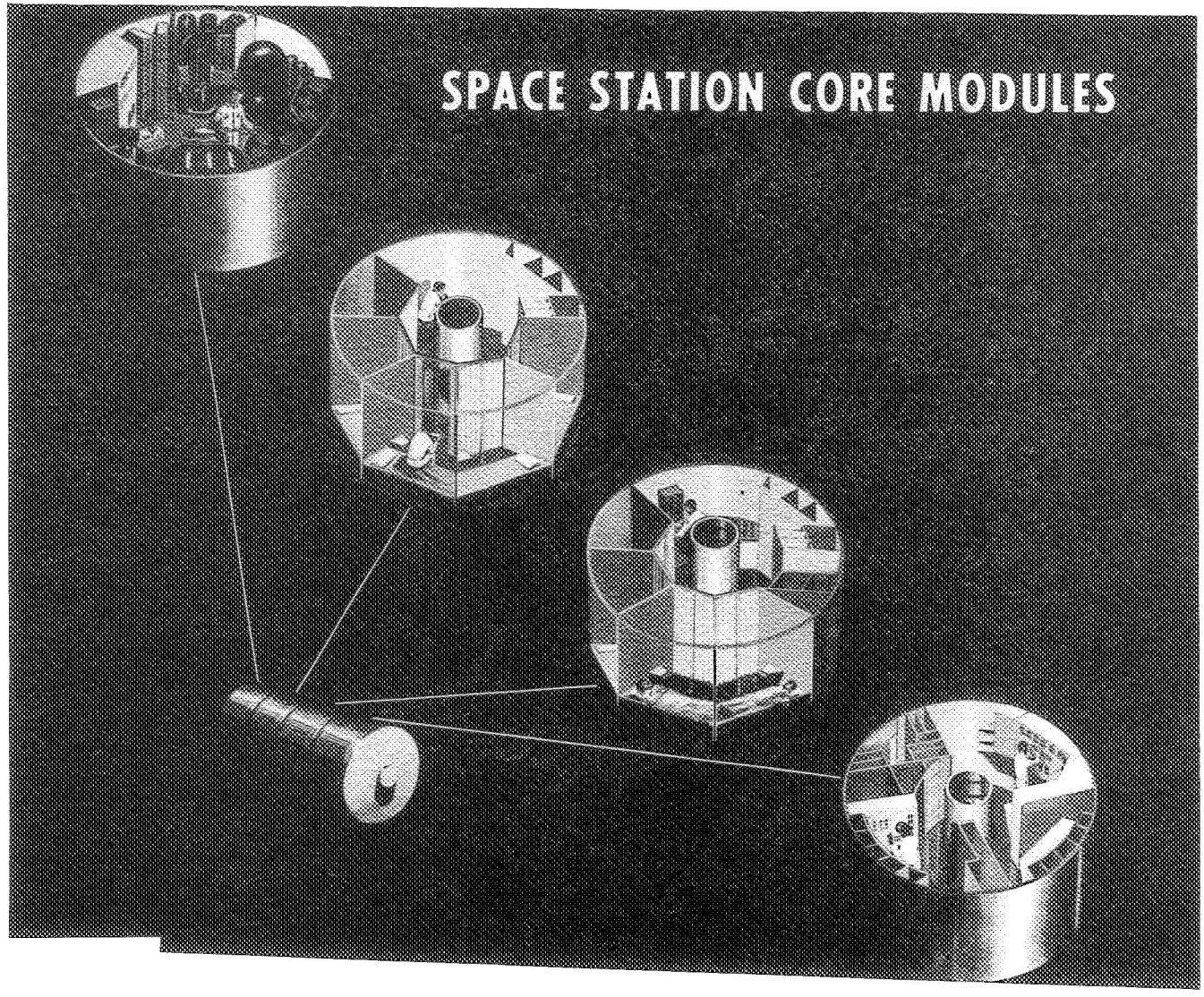


FIGURE 5

R & D ADVANCED TECHNOLOGY LABORATORY

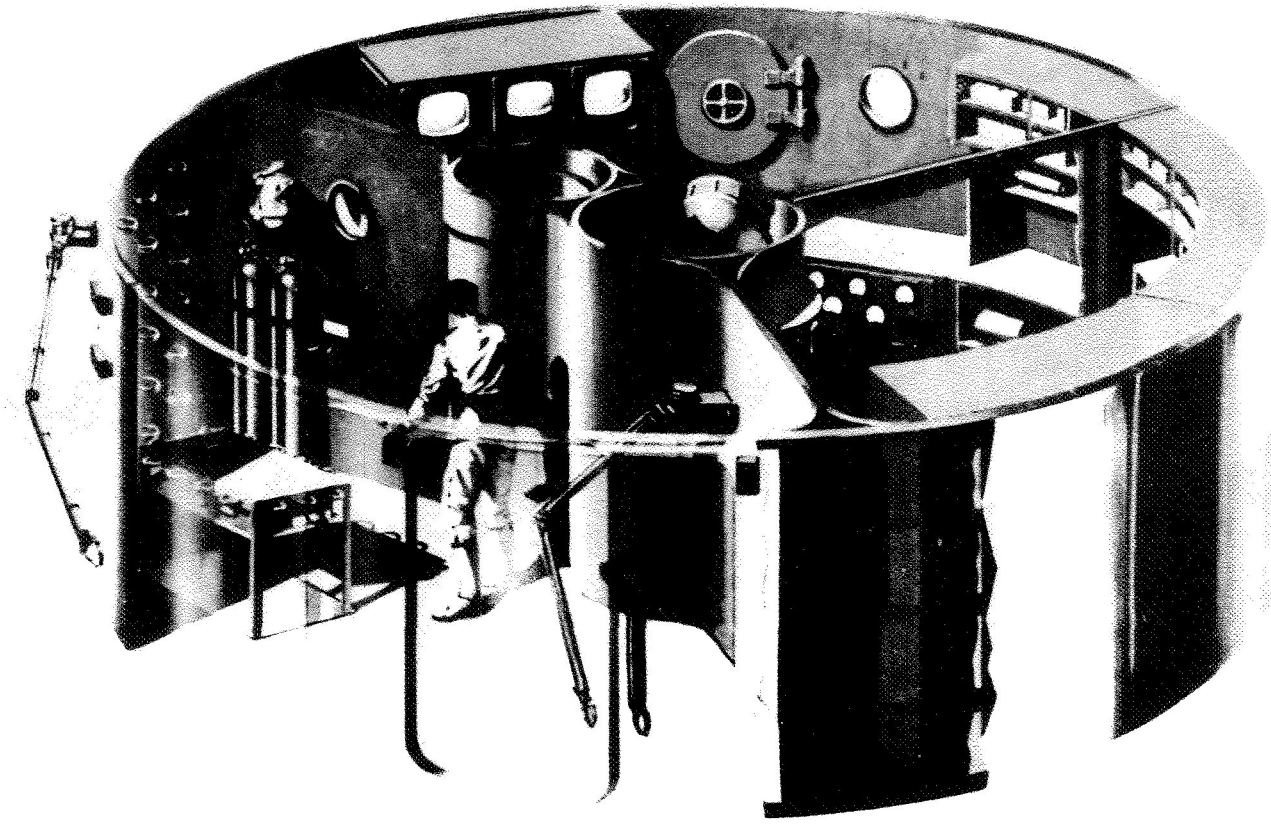


FIGURE 6

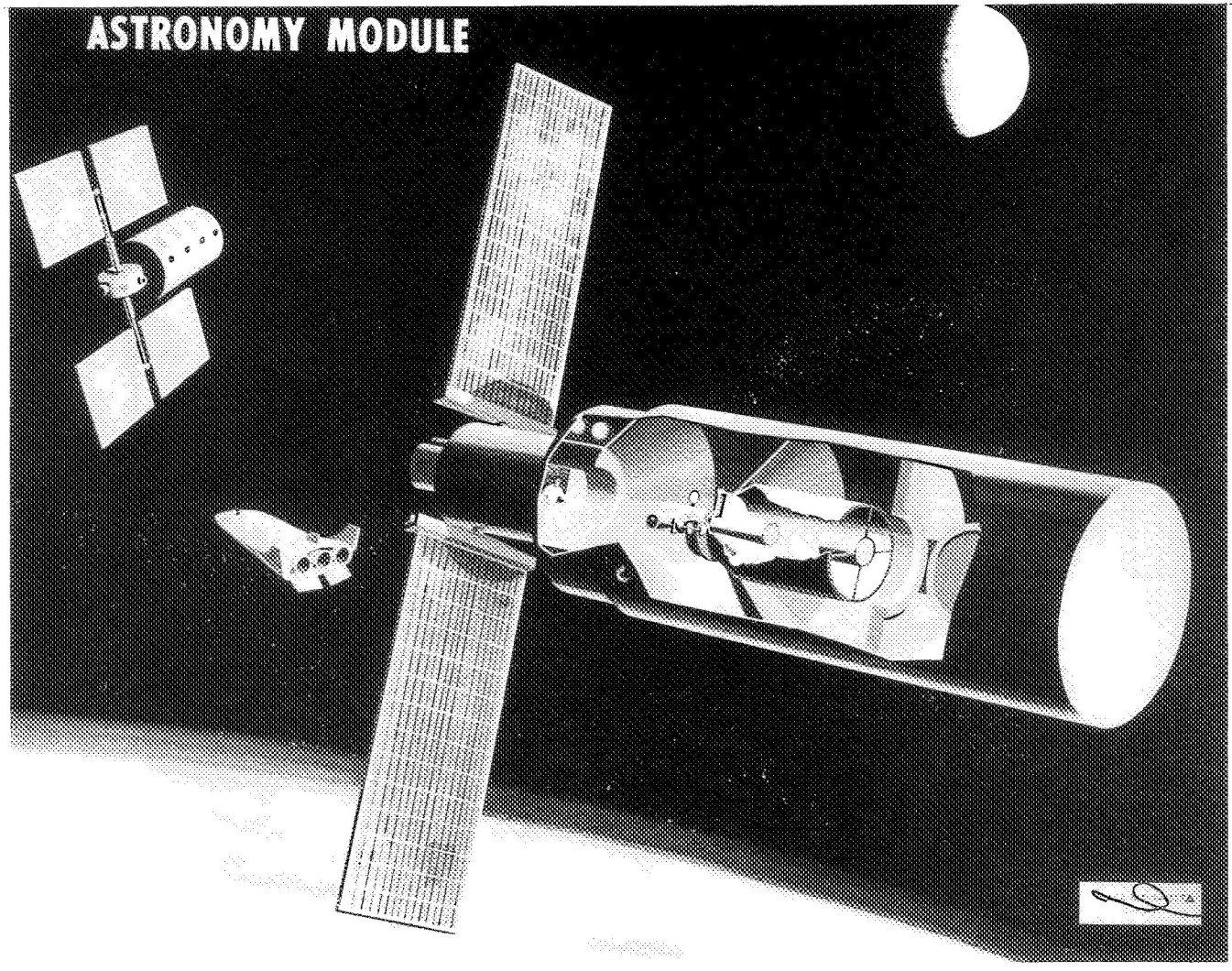


FIGURE 7

INTEGRAL LAUNCH AND REENTRY VEHICLE

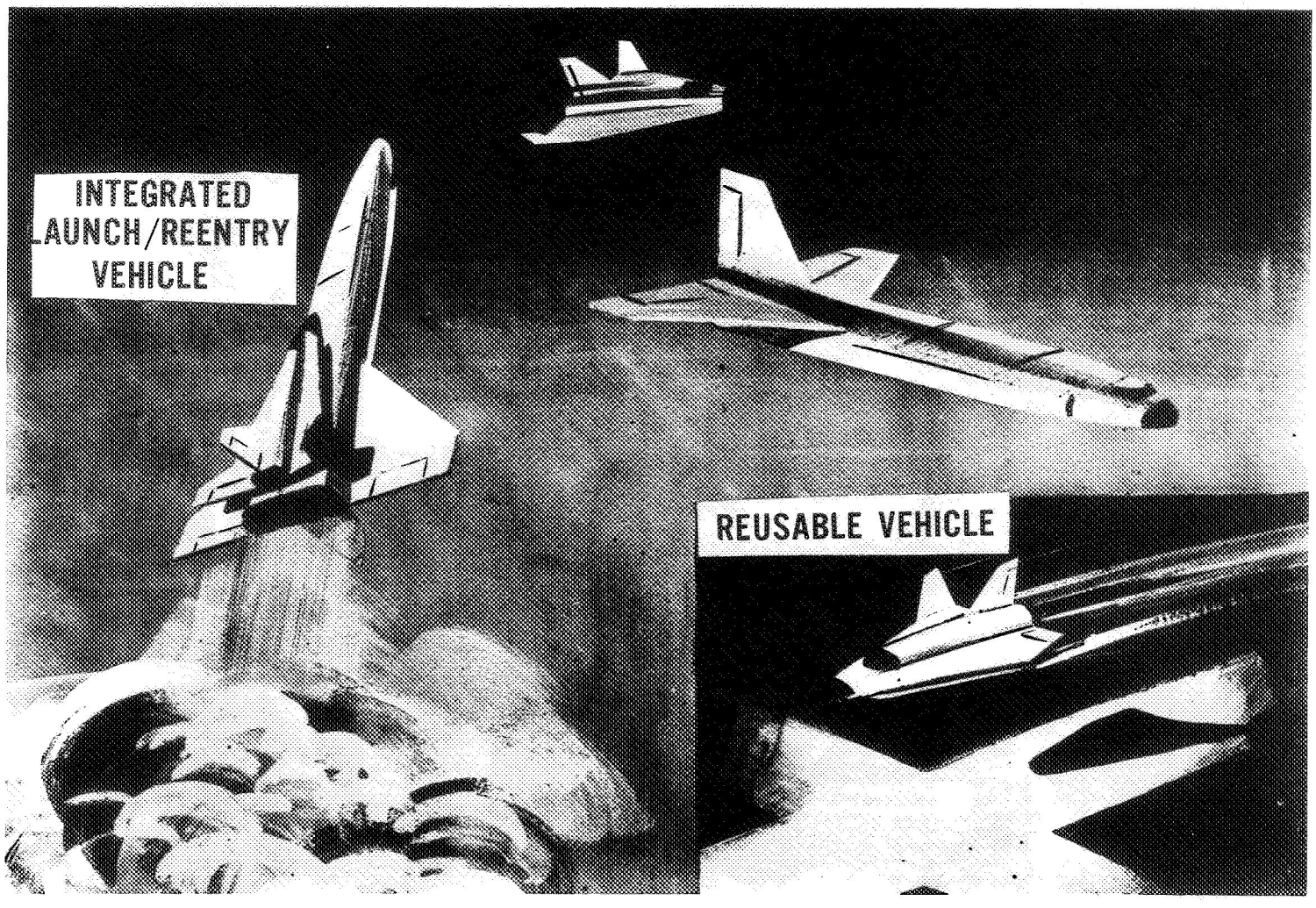


FIGURE 8

SPACE SHUTTLE

OPERATIONAL CONCEPT

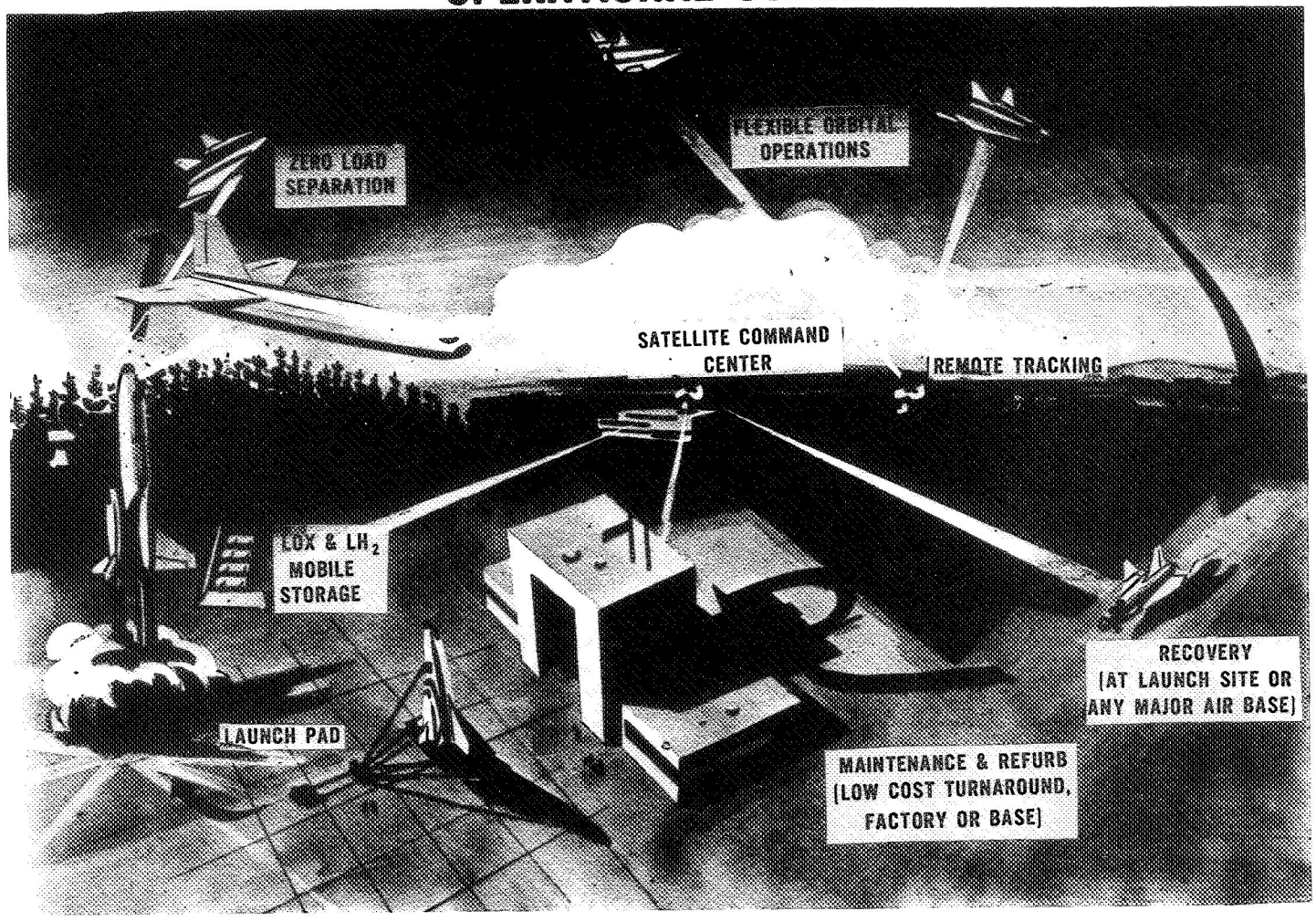

ZERO LOAD SEPARATION
FLEXIBLE ORBITAL OPERATIONS
SATELLITE COMMAND CENTER
REMOTE TRACKING
LOX & LH2 MOBILE STORAGE
RECOVERY (AT LAUNCH SITE OR ANY MAJOR AIR BASE)
LAUNCH PAD
MAINTENANCE & REFURB (LOW COST TURNAROUND, FACTORY OR BASE)

FIGURE 9

PROGRAM APPROACH TO MATERIALS PROCESSING IN SPACE

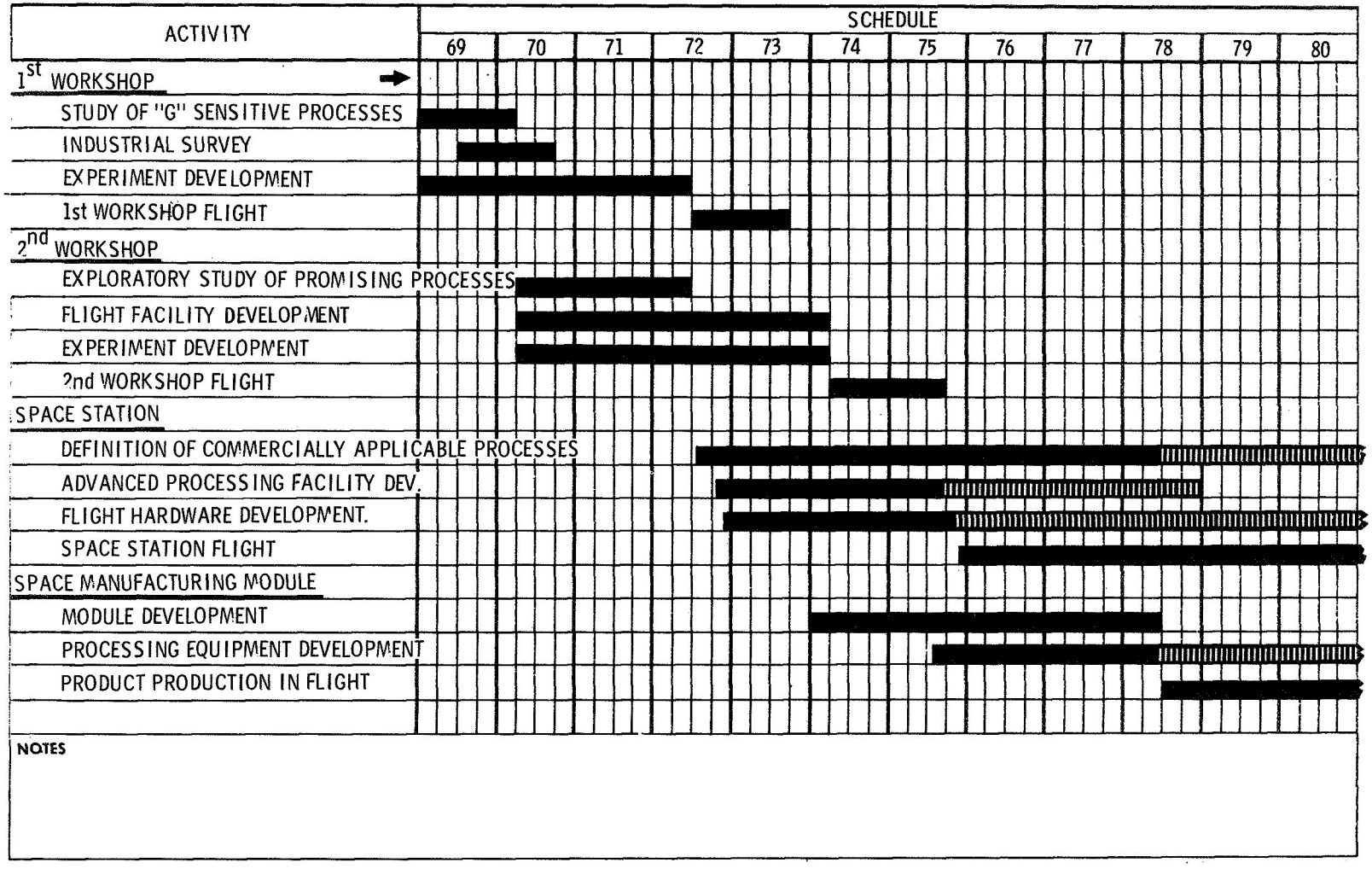
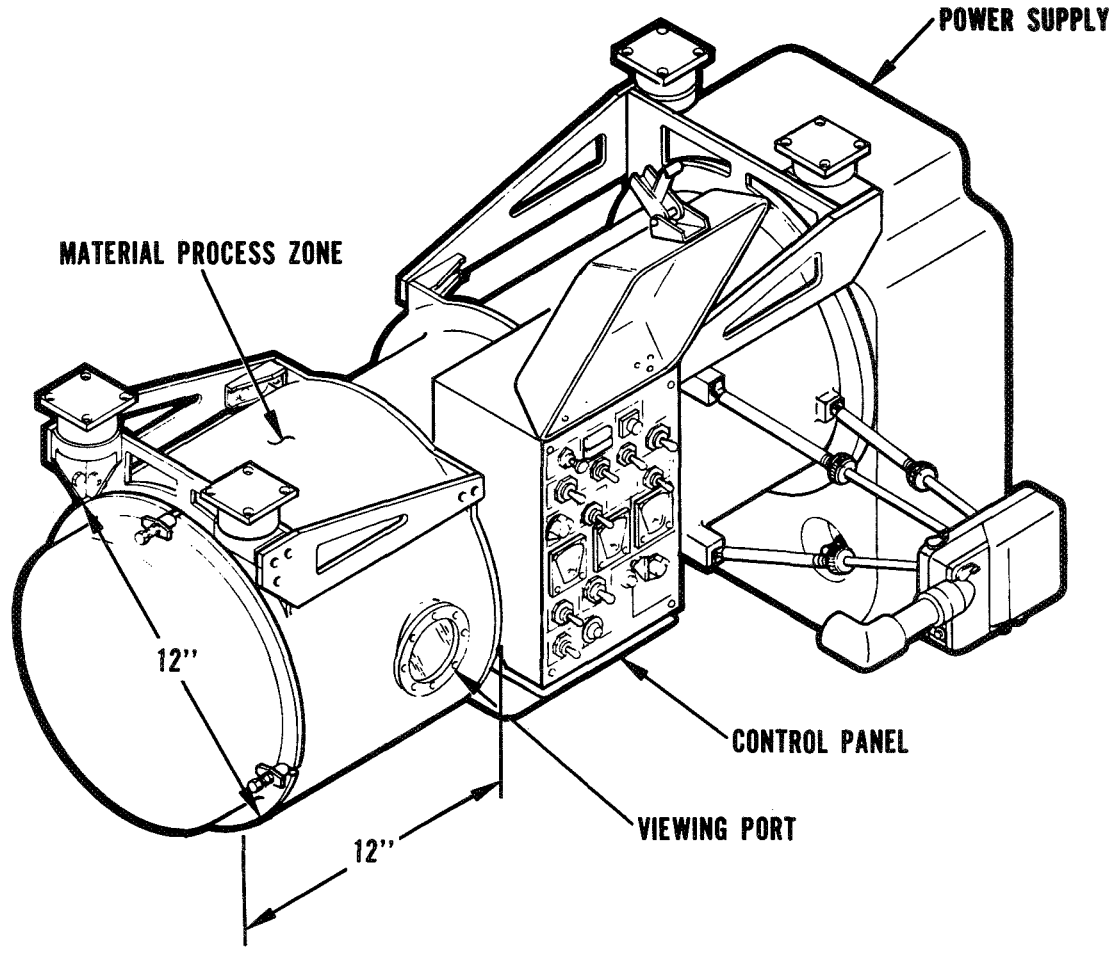


FIGURE 10

MSFC STUDIES ON SPACE PROCESSING OF MATERIALS

STUDY	INVESTIGATOR	ORGANIZATION	PURPOSE
THEORETICAL STUDIES			
• CRYSTAL WHISKER GROWTH	DR. DAVIS	UNIV. OF ALA.	• STUDY EFFECT OF GRAVITY ON CRYSTAL WHISKER GROWTH
• ZERO "G" EFFECT ON CRYSTAL GROWTH	DR. ROY	UNIV OF ALA.	• THEO INVEST. OF SOLIDIFICATION MECHANISMS IN ZERO "G"
• INVESTIGATION OF GAS MANAGEMENT	DR. BAUER	GEORGIA TECH	• EXAMINE GAS - LIQUID INTERACTION IN ZERO GRAVITY
• SPACE ENVIRONMENT EFFECTS ON SOLIDIFICATION	DR. GRODZKA	LOCKHEED	• EFFECTS OF SURFACE TENSION & CONVECTION ON CRYSTAL GROWTH
• SPACE ENVIRONMENT EFFECTS ON DISPERSION IN METALS	DRs FABINIAK	CORNELL AERO	• GROWTH CHARACTERISTICS OF MATERIALS IN ZERO "G"
STUDIES OF SPECIFIC PROCESSES			
• CRYSTAL GROWTH	DR. FROST	G. E.	• DEFINITION OF CRYSTAL GROWTH EXP. FOR FLIGHT
• ZERO "G" CRYSTAL GROWTH	BANNISTER	S. S. L. (MSFC)	• PHOTOGRAPHING CRYSTAL GROWTH IN ZERO "G"
• DROP TOWER EXPERMINTATION	BANNISTER HOPPES	S. S. L. (MSFC) M. E.	• STUDY SOLIDIFICATION OF MOLTEN METALS IN FREE-FALL
• GROWTH OF CRYSTALLINE MATERIALS	BANNISTER	S. S. L. (MSFC)	• LAB. STUDIES OF CRYSTALLINE MATERIALS FORMATION
SURVEY STUDIES			
• PROCESSES FOR SPACE MANUFACTURING	DR. STEURER	G D/CONVAIR	• IDENTIFY PROMISING "G" SENSITIVE PROCESSES FOR FLIGHT
• USE OF OUTER SPACE - DESIGN COURSE	DR. SHAW	CARNEGIE-MELLON	• SENIOR CLASS PROJECT TO IDENTIFY POTENIAL USES OF SPACE FOR IND. APP.
INDUSTRIAL CANVASS	LAKE	MSFC	• SURVEY OF SCIENCE & INDUSTRY INTERESTS IN SPACE PROCESSING & MANUFACTURING
FACILITY DEVELPOPMENT			
• DESIGN STUDIES OF EXPERIMENTAL SUPPORT HARDWARE	DR. FROST MC CREIGHT	G. E.	• DESIGN OF POSITIONING, HEATING, COOLING & SEPARATION EXP. EQUIP.
• DESIGN STUDIES OF PROCESS CHAMBER	RASQUIN	M. E. (MSFC)	• DESIGN & FAB. OF PROCESSING CHAMBER FOR 2ND WORKSHOP
SUPPORT OF AAP EXPERIMENTS			
• CRYSTAL GROWTH IN ZERO "G"	DR. MAZELSKY	WESTINGHOUSE	• DEVELOP TECHNIQUES & EQUIP. FOR AAP CRYSTAL GROWTH EXP.
• SPHERICAL CASTING & COMPOSITE MELTING	DR. WECHSLER	A. D. LITTLE	• DEVELOP TECHNIQUES & EG. FOR BLENDING & CASTING OF MATERIALS IN SPACE
• METALS MELTING	PARKS	M. E. (MSFC)	• EXP. DEF. TO EVALUATE MELTING & FREEZING OF METALS IN ZERO "G"

FIGURE 11



MANUFACTURING PROCESS CHAMBER

FIGURE 12

SATURN WORKSHOP I INVESTIGATIONS

- METALS MELTING
- EXOTHERMIC BRAZING
- SINGLE CRYSTAL GROWTH
- COMPOSITE CASTING
- ZERO GRAVITY FLAMMABILITY
- SPHERICAL CASTING

FIGURE 13

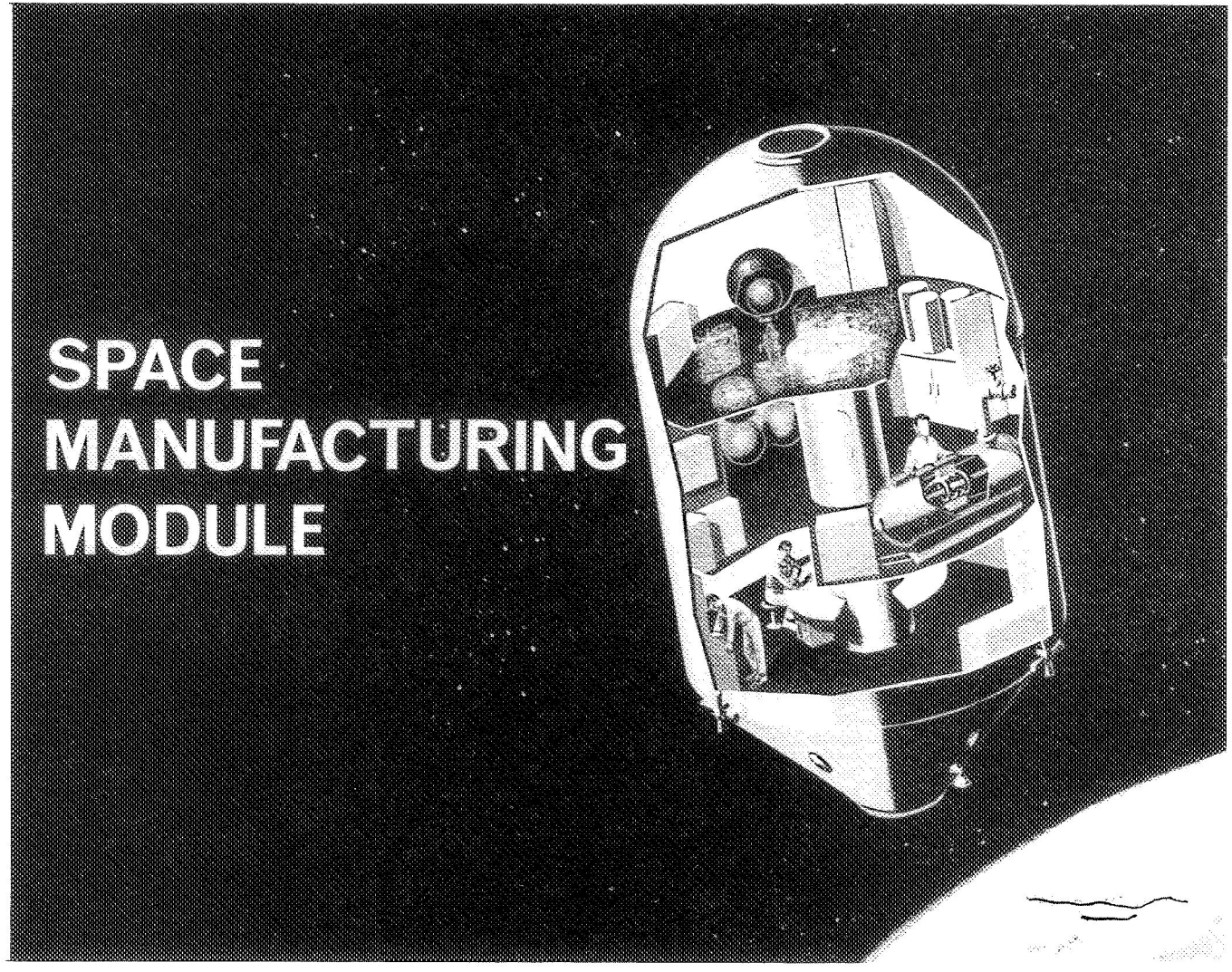


FIGURE 14

ANNOUNCEMENT OF FLIGHT OPPORTUNITY

- MISSION CAPABILITY AND CHARACTERISTICS
- CATEGORY OF INVESTIGATIONS SOLICITED
- INSTRUCTIONS FOR PREPARING PROPOSALS
- SCHEDULE OF MILESTONES FOR FLIGHT

FIGURE 15

SELECTION OF PROPOSED FLIGHT EXPERIMENTS

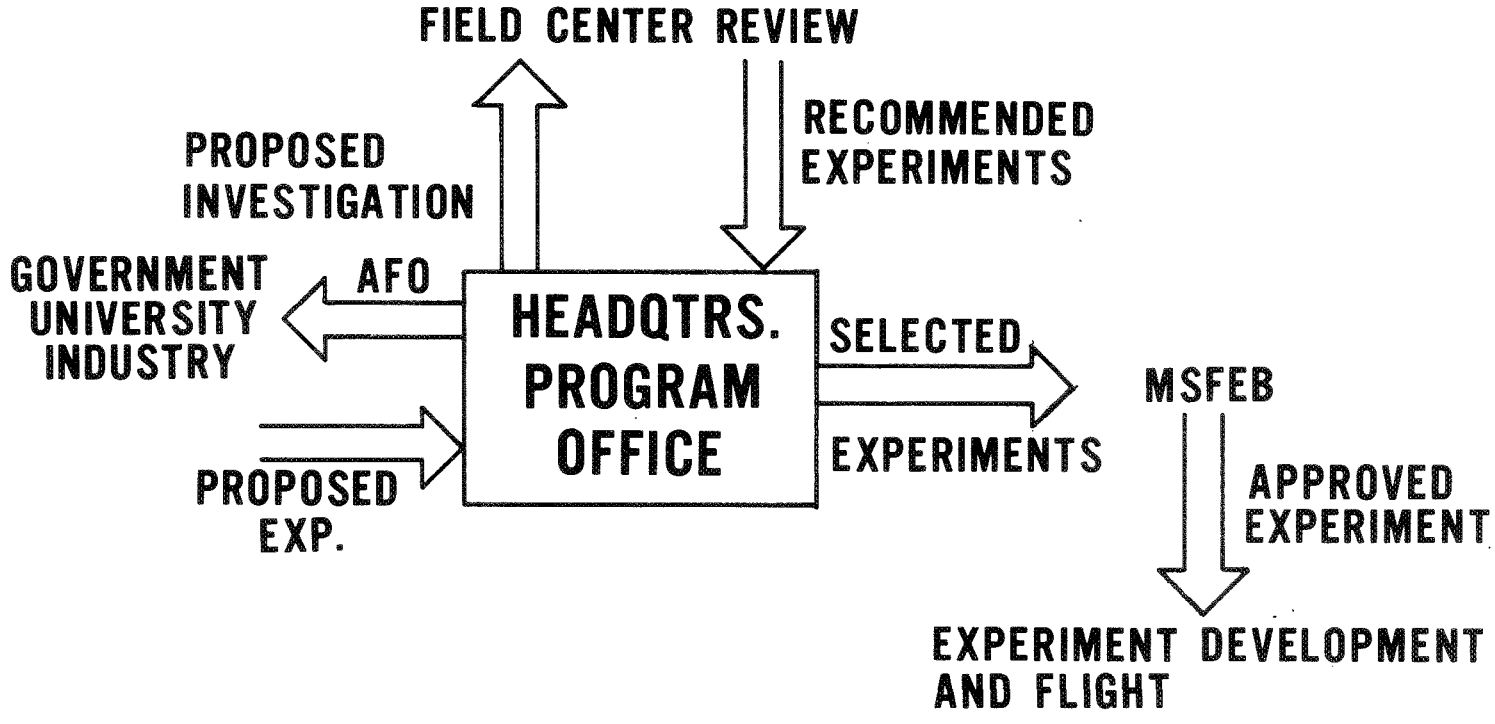


FIGURE 16

INDUSTRY-GOVERNMENT RELATIONS IN SPACE MANUFACTURING

CATEGORY	CHARACTERISTIC OF PROJECT	SUGGESTED POLICY GUIDLINES
GOVERNMENT PROCURED R&D	• GOVERNMENT SOLICITED RESEARCH • COMPETIVE SELECTION OF CONTRACT SUPPORT • GOVERNMENT FUNDED INVESTIGATION	• UNDISTURBED PERIOD OF ACCESS TO DATA • RESULTS PUBLISHED FOR GENERAL USE • DATA & INVENTIONS RETAINED BY GOVERNMENT
SPONSORED FLIGHT RESEARCH IN PRIVATELY DEVELOPED AREA	• OUTGROWTH OF PRIVATE RESEARCH • GOVERNMENT SUPPORT SOLICITED BY COMPANY • DEVELOPMENT THRU SOLE SOURCE PROCUREMENT • GOVERNMENT SPONSORED FLIGHT IMPLEMENTATION	• PRIOR WORK PROTECTED • DATA AND INVENTIONS RETAINED BY GOVERNMENT • WAIVER OF PATENT RIGHTS & DISCLOSURE OF DATA NEGOTIABLE
FLIGHT OF PRIVATLEY OWNED DEVELOPED INVESTIGATION OF PROCESSES	• FLIGHT PROGRAM PRIVATELY CONCEIVED AND DEVELOPED • INTEGRATED & FLOWN AT GOVERNMENT EXPENSE • RESULTS INTENDED FOR PROPRIETARY DEVELOPMENT	• PROPRIETARY INTERESTS PROTECTED • ROYALTY FREE RIGHTS RESERVED BY GOVERNMENT
PRODUCTION FOR COMMERCIAL MARKETING	• PROCESS & PRODUCTION PRIVATELY DEVELOPED • PRIVATE RENTAL OF SPACE FACILITIES • PRODUCT MARKETED COMMERCIALLY	• PRECEDENTS PROVIDEED BY WIND TUNNEL ACT COMSAT AGREEMENT • PRIVATE INTERESTS PRESERVED

FIGURE 17